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Tail Length to Tail Weight Relationships for Louisiana White Shrimp in 1977

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Data and Analysis Methods

Samples of white shrimp P. setiferus (Linnaeus) collected in July to December of 1977 were used to study length to weight relations. The samples were from three sources:

(1) 5176 shrimp taken near release sites during tagging for mark-recapture experiments at Caillou Lake and offshore Louisiana (these were not tagged and released),

(2) 6699 shrimp from landings at commercial fish houses, and

(3) 3862 marked shrimp which were released and recaptured.

The first two sources were "length-weight samples" used in the calculation of length to weight conversions. The third source was used for comparison of tagged shrimp versus untagged shrimp. All shrimp were dead when measured. The Caillou Lake samples were usually measured the day they were caught. Offshore Louisiana samples were frozen, then measured several weeks later. Samples at fish houses were measured as they were selected. Recaptured shrimp were genearlly kept on ice, refrigerated or frozen until they were measured several days later.

The data set included shrimp ranging from 25 to 116 mm in tail length and .4 to 38.2 g in tail weight. (Note: hereafter "length" and "weight" refer to measurements made on tails only. "Tail" refers to the portion of the shrimp from the anterior margin of the first abdominal segment to the posterior margin of the telson.) In each month, an effort was made to measure all sizes of shrimp ; thus the range of lengths is approximately the same over months.

The power function $\hat{W} = \hat{a}L^{\hat{b}}$ was used to describe various portions of the data, where $\hat{W}$ = expected tail weight at length L, and $\hat{a}$ and $\hat{b}$ are parameter estimates. Traditionally, the model assumed is $W = aL^{b}\varepsilon$ where ε is lognormally distributed. However, these data more appropriately support the model $W = aL^{b}+\epsilon$ where ϵ is normally distributed. A nonlinear least squares fitting procedure was used to fit this model.

The length-weight relations were investigated for differences between data sources, sexes, and months. Comparisons among different curves were made two ways: (1) visually and (2) with Rao's chi-square test on the parameter estimates $\hat{a}$ and $\hat{b}$ (Rao 1973, p. 389.) There are no statistical tests which are generally appropriate for these parameters when estimated by nonlinear methods. The distributions of the parameter estimates and the predicted values are not known, and the estimates of a and b are highly correlated. Rao's test was used here to investigate possible differences among curves, but the test is based on asymptotic normality of the parameter estimates. The results should not be used for definitive statements unless more is known about the joint distribution of the parameter estimates. (The same would hold for other tests based on normality which are typically used with linear regressions.)

Because of the large number of samples involved, visual inspection was often not followed by statistical tests when the results of the visual inspection were clear.

Discussion

Visual inspections of scatter plots detected no systematic differences between samples from release sites and those from commercial fish houses; thus data from these two sources were combined for further analysis. Data from marked and recaptured shrimp appeared very different from samples from fish houses and release sites, therefore, these data were analyzed separately.

1. Shrimp from length-weight samples (not marked and released)

For August to November, no clear sexual differences in length-weight relations can be seen from visual inspection of the data and the fitted curves for separate months. Within the range of most of the data (less than 95 mm), the predicted weights at length for the two sexes generally differ by less than .2 grams. Predicted weights are between approximately 1 and 25 g. For shrimp longer than 95 mm the difference between the predicted weights increases to greater than 1 g. These predicted weights are over 25 g. There are, however, few data in this range and the variances of the observed weights is large, thus making the estimates of weight imprecise.

Sexual differences are indicated by visual inspection of the July and December data and curves. For shrimp 65 to 80 mm in tail length, the observed weights of males are generally less than those of females of the same length; predicted weights are up to .5 g less for males.

Rao's X^2 test shows differences between the sexes ($p > .95$) for the parameters a and b in July, August, September and December. The test shows no sexual difference for October and November parameters. However, it should be remembered that these tests only give general indications and not exact probabilities.

Comparisons were made among monthly curves and data keeping the sexes separate. Pairwise statistical tests were not made, but there are clear differences when all months are compared together(visually and with Rao's test). For both sexes the July, August and September curves are similar; the October curve predicts the heaviest weights (over all lengths); and the November and December curves predict the lightest weights for medium-length shrimp. The largest difference between predicted weight for different months is 2g for shrimp smaller than 95 mm.

Though some sexual differences are suggested by these data, these differences are not consistent over months and lengths are not of practical significance (generally less than .2g), and are small compared to the monthly differences. Thus useful length-to-weight conversions are best derived by combining sexes within months.

The relationship among monthly curves is the same for sexes combined as for sexes separate: the October curve predicts the heaviest weights for lengths smaller than 95 mm, while the November and December curves predict the lightest weights. Differences in predicted weights at length for different months are 1 g or less. For longer shrimp, the curves cross and comparisons are not very meaningful as there are few data in that size range and variances are large.

The fitted curves for July through October estimate well the mean weight at length for the entire range of lengths observed in that month. However, the curves for November and December underestimate the mean weight at length for shrimp smaller than 60 mm by as much as .3 g, but they correctly estimate weights of longer shrimp. For these months, the standard technique of transforming the data to logarithms and fitting a linear regression also produced curves which do not visually fit the entire range of data. Apparently, a single power curve is not appropriate to describe these data over the entire range of lengths. A separate curve fitted to all November and December data smaller than 50mm does estimate the weights of small shrimp well in both months. This curve can be extrapolated in each month up to the point where it crosses the original curve for that month. Thus there are separate curves for 25 to 52 mm and 53 to 116 mm in November and for 25 to 62 mm and 63-116 mm in December. The monthly parameters and support plane 90% confidence intervals (Conway, et al. 1970) for the length-weight model $W=aL^b$ with sexes combined are:

Month	$\hat{a}$	Limits Upper and Lower	$\hat{b}$	Limits Upper and Lower	Length Range	N
July	.00000917	.00000836 .00000999	3.196	3.176 3.215	25-116 mm	2128
August	.00001370	.00001255 .00001483	3.107	3.088 3.126	25-116 mm	2334
September	.00001250	.00001139 .00001384	3.129	3.105 3.154	25-116 mm	3529
October	.00000930	.00000815 .00001045	3.202	3.174 3.229	25-116 mm	1217
November	.00003990	.00003200 .00004310	2.819	2.754 3.900	25-52 mm	404
	.00000673	.00000597 .00000749	3.265	3.241 3.290	53-116 mm	992
December	.00003990	.00003200 .00004310	2.819	2.754 3.900	25-62 mm	404
	.00000387	.00000336 .00000328	3.383	3.354 3.412	63-116 mm	1254

The difference between the July through October curves and the November through December curves suggests a possible temperature effect on the length-weight relations. In November and December, the predicted weights at length decrease (for shrimp smaller than 95 mm), reversing the July to October trend of increasingly heavy predicted weights. Correspondingly, the hourly surface temperatures recorded in Caillou Lake in 1977 (Phares, 1978) were all above 25° C from June through October 3; then the temperatures fell sharply to below 25° C and steadily dropped through December.

In applications, separate monthly length-weight curves are not always desired; or a curve may be needed for some month between January and June. Since there are significant monthly differences, it is not correct to fit a composite curve. If a single curve must be used for the year, the July curve should be applied, as it is generally in the middle of the spread of the curves for July through December. In lieu of additional data, this curve must also be applied from January to June.

2. <u>Marked and recaptured shrimp</u>

All tagged shrimp and length-weight samples should be from the same population since all were caught in Louisiana waters during the last 6 months of 1977. The released shrimp and the length-weight samples at tagging sites were usually caught in the same tows. Thus no inherent difference exists between tagged shrimp and those used for length-weight samples. However, in all months the length-to-weight curves overestimate the weights of more than 75% of the recaptured shrimp, and the range of weight at length for recaptures from October to December are up to twice as wide as the ranges for length-weight samples. I noted a similar discrepancy between (total) length-weight relations for stained and unstained pink shrimp from the Tortugas grounds (stained shrimp from a mark-recapture study by Berry, 1967, and unstained shrimp from Fontaine, 1971).

The observed length-weight relations of marked and unmarked shrimp may be different because marked and unmarked shrimp actually grow differently or because the recaptured shrimp are generally not measured fresh. It can be several hours or days between the recapture of a marked shrimp, its discovery and its measuring or preservation; during this time, it may undergo considerable handling and desiccation. The conversions derived from length-weight samples can still be properly applied to release lengths in the mark-recapture experiments in order to estimate release weight.

Conclusions and Summary

1) Sexual differences in length-weight curves are not of practical significance; sexes should be combined.
2) There are significant differences among monthly curves with sexes combined; thus fitting a composite curve for all months is not correct.
3) Data for January-June were not collected so that the length-weight relations are unknown for these 6 months. Of those available, the July curve is probably the one to use for those months where data is unavailable, since it lies in the approximate center of the monthly curves.
4) The October curve predicts the heaviest weights and the December curve the lightest weights for a given length (up to 95 mm).
5) The difference between predicted weights in separate months is 1 g or less for shrimp smaller than 95 mm in length.
6) The same function should not be used to estimate the weight of both small and large shrimp in November and December; a separate curve for small shrimp is required.
7) Observed length-weight relations of tagged and recaptured shrimp are different from those observed for shrimp which were not tagged.

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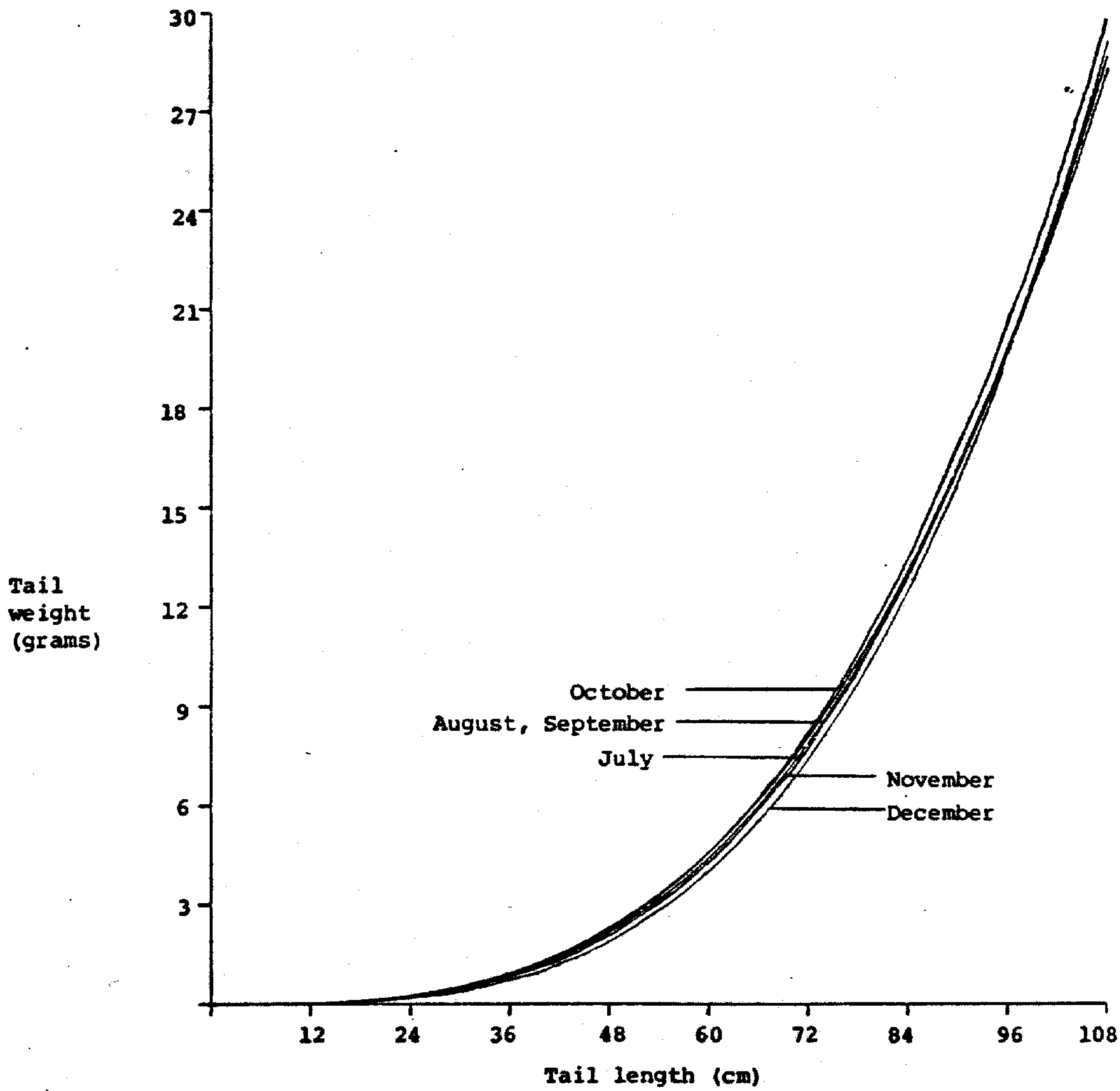

Figure 1. Monthly length-weight relationships for white shrimp.